A Radar Study of the Backup Martian Landing Sites

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The Goldstone radar system at DSS 14 was used to probe the Martian surface at 8495 MHz in a narrow strip between -6 deg and -2 deg latitude. The Viking C landing sites lie in this strip, and their altitudes, rms surface slope, and reflectivity are presented here.

The latest Martian opposition (condition of closest approach) occurred on December 9, 1975. At that time the sub-Earth point on Mars was at a latitude of -1 deg, traveling south to a minimum of -6 deg in mid-January, 1976. Turning northward, the sub-Earth point reached a latitude of 24 deg by July 1976 (the planned time of the first Viking landing). The backup landing sites, to be considered in the event of a failure on the first landing, were in a narrow strip just south of the Martian equator. The region contained possible landing sites that could be probed by radar at a time when the sensitivity of Earth-based radars was near a maximum (the sensitivity decreases as the fourth power of the distance).

These backup sites, known as "C" sites, were probed at a frequency of 8495 MHz. The R&D X-band transmitter at DSS 14, Goldstone, California, was used as a signal source. The 64-m antenna at DSS 14 was used for transmission and reception. Small cells 25 km E–W by 150 km N–S were isolated on the Martian surface. This isolation was accomplished by (1) phase modulating a CW signal with a pseudorandom sequence upon transmission, thereby facilitating differential range measurements; (2) Fourier analyzing the output of each of 32 range gates to produce a 64-point spectrum every 65 ms. About 461 spectra were combined to produce an average spectrum every 30 seconds. The basic bit length of the phase modulation was 8 μs. The maximum doppler shift (due to the rotation of Mars) measurable was 984 Hz, so the maximum resolution was 15.6 Hz. This corresponds to an E–W resolution of 0.07 deg in longitude along the doppler equator within 10 deg of the sub-Earth point. The resolution was dropped to 0.5 deg throughout the data analysis to decrease the effects of receiver noise. The N–S resolution, determined by the modulation bit length, was about 2.5 deg. These resolutions correspond to the cell size quoted above.

The 30-second data frames collected during a particular observing run were combined to yield backscatter functions (reflected power versus the angle of incidence) for each 0.5-deg region located along the doppler equator. Each function was analyzed to determine residual range,

the roughness parameter C, and the reflectivity ρ. The parameters C and ρ are referred to as the scattering parameters. The manner in which the cells are isolated on the Martian surface and the techniques of determining range and the scattering parameters are described in detail in Refs. 1 and 2.

Observation runs were made between 20 December 1975 and 25 February 1976 for the purpose of studying the Viking C sites. The results of 12 runs are condensed here by combining results within three latitude bands, each 2 deg wide. The bands are centered at latitudes of −6 deg, −4 deg, and −2 deg. All numerical results at a particular longitude, pertaining to a particular parameter and located within 1 deg in latitude of the center of the strip, were averaged together. The results are presented in Figs. 1 and 2. Figure 1 corresponds to the strip 2 deg wide N–S centered at −6 deg latitude, while Fig. 2 corresponds to the strip centered at −4 deg, with one exception: all data in Fig. 2 for longitudes greater than 300 deg apply to the strip centered at −2 deg latitude. The residual ranges have been converted to altitude in km. The reference surface corresponding to 0-km altitude is the ellipsoid of Standish (Ref. 3) with a radial scale of 3397.515 km. The Martian ephemeris used for the final analysis was obtained from the JPL ephemeris DE 96, modified by a small range polynomial determined by M. Standish using, in part, the observations described herein. The roughness parameter C has been converted to θ_r, the estimate of the rms slope of the surface, where $\theta_r = C^{-1/2}$ radians. The one-standard-deviation uncertainty in altitude is less than 0.5 km. The plot of each θ_r and ρ in Figs. 1 and 2 is a vertical bar. The middle of the bar represents the estimate of the parameter. The length of the bar represents one standard deviation above and below the estimate. (Any bar exceeding 8 deg or 12 percent is truncated). Hence there is a 68-percent probability that the true value of the parameter lies on the bar.

The positions of the seven C sites are marked on the appropriate figures. The site nomenclature and position are those in use as of 22 April 1976. In some cases the site is actually a region and is marked at two longitudes or latitudes.

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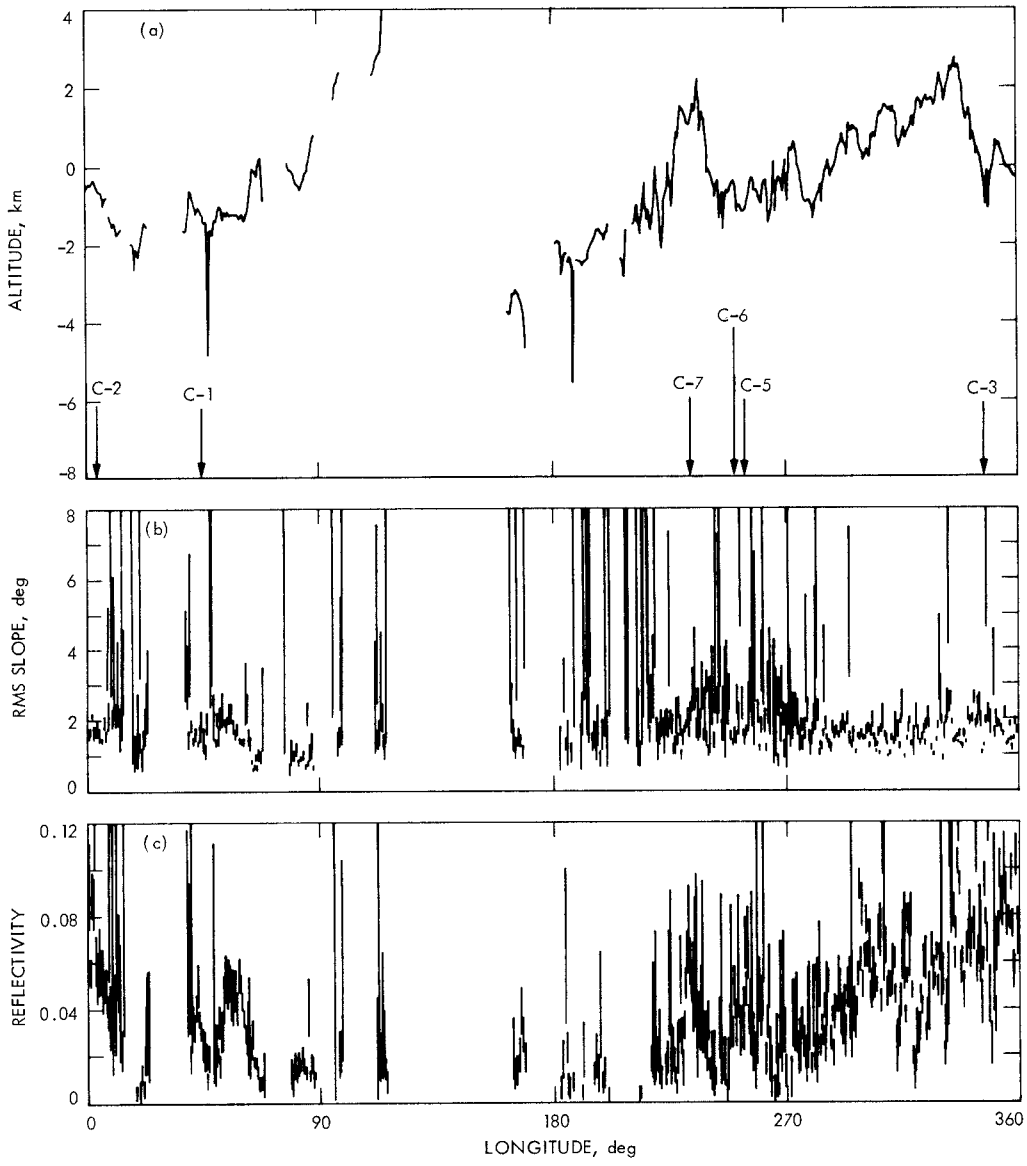

Fig. 1. Martian radar surface properties as seen by radar at 8495 MHz, −6 deg latitude: (a) altitude, (b) rms slope, and (c) reflectivity. Longitudes of the C sites are marked

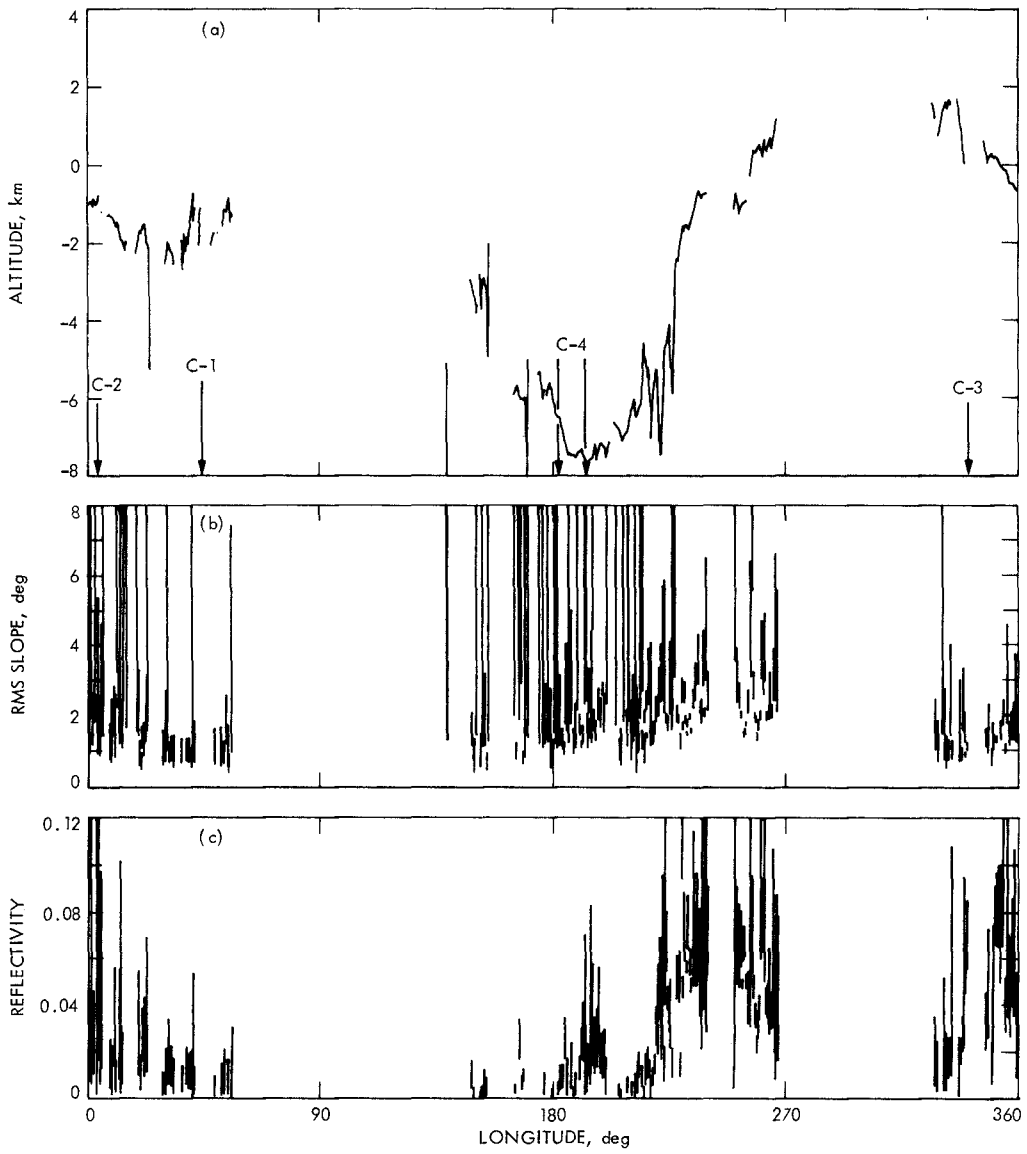

Fig. 2. Martian radar surface properties as seen by radar at 8495 MHz, −4 deg latitude, or −2 deg latituue (longitude > 300 deg): (a) altitude, (b) rms slope, and (c) reflectivity. Longitudes for the C sites are marked